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**Kanai**

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(54) **POWER SUPPLY SYSTEM**

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(52) **U.S. Cl.** ..... **700/288; 700/287**  
(58) **Field of Classification Search** ..... **700/288**  
See application file for complete search history.

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(57) **ABSTRACT**

In a power supply system (10) having a cogeneration unit (12) equipped with an internal combustion engine (12a) and a generator (12b) to generate power to be supplied to a power destination and hot water to be supplied to a hot water destination, there are provided with a natural energy generation unit (14) that generates power with natural energy, a power supply unit (20) that receives the power generated by the generator and natural energy generation unit to supply the received power to the power destination; a voltage detector (22a) that detects voltage (V1) of the power flowing through an connecting bus (22), and an electric heater (121). The power supply unit (20) controls operation of the electric heater based on the detected connecting bus power voltage (V1), thereby effectively utilizing surplus electricity without transmitting back it to a commercial power source.

**11 Claims, 4 Drawing Sheets**

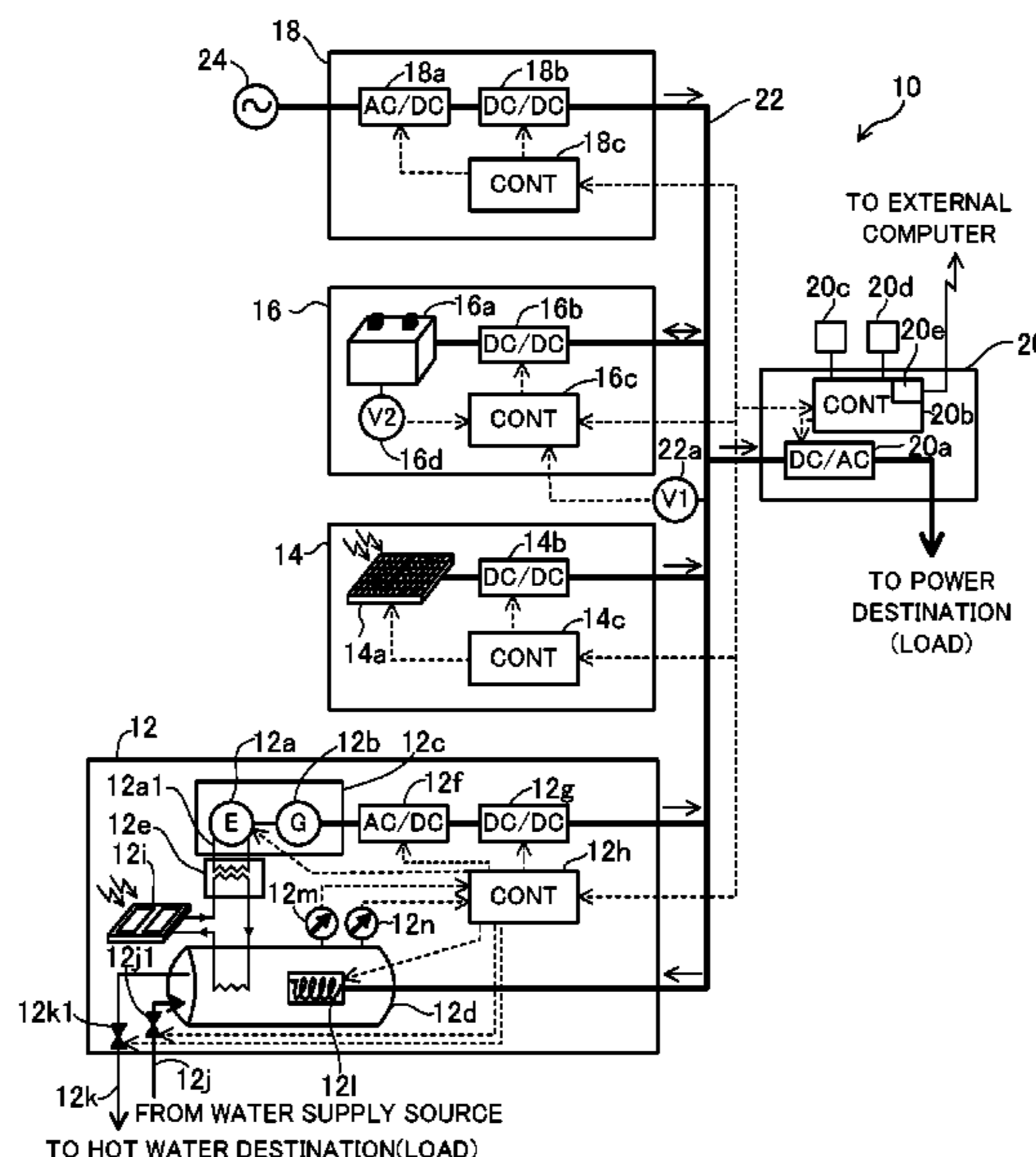
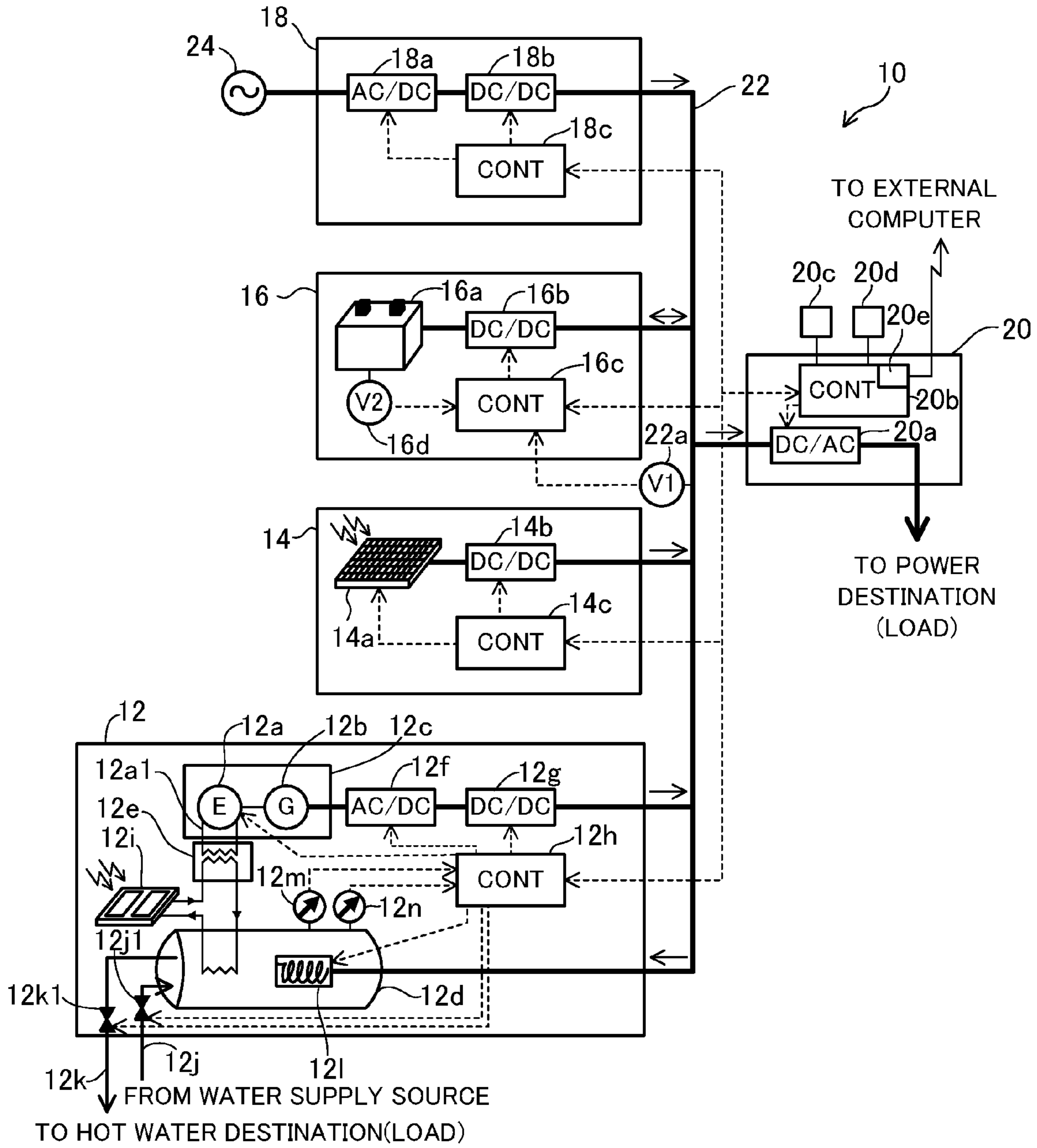
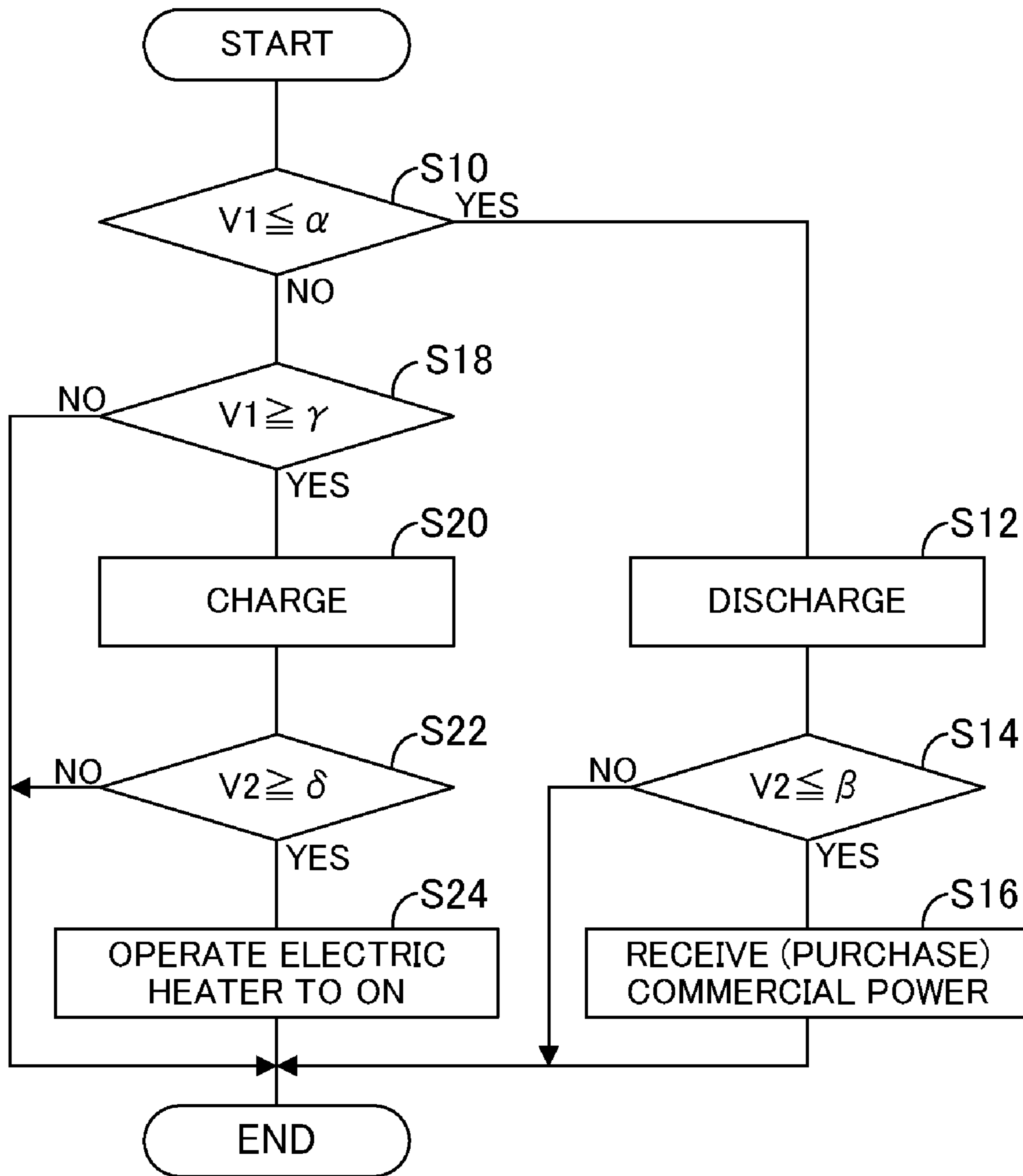


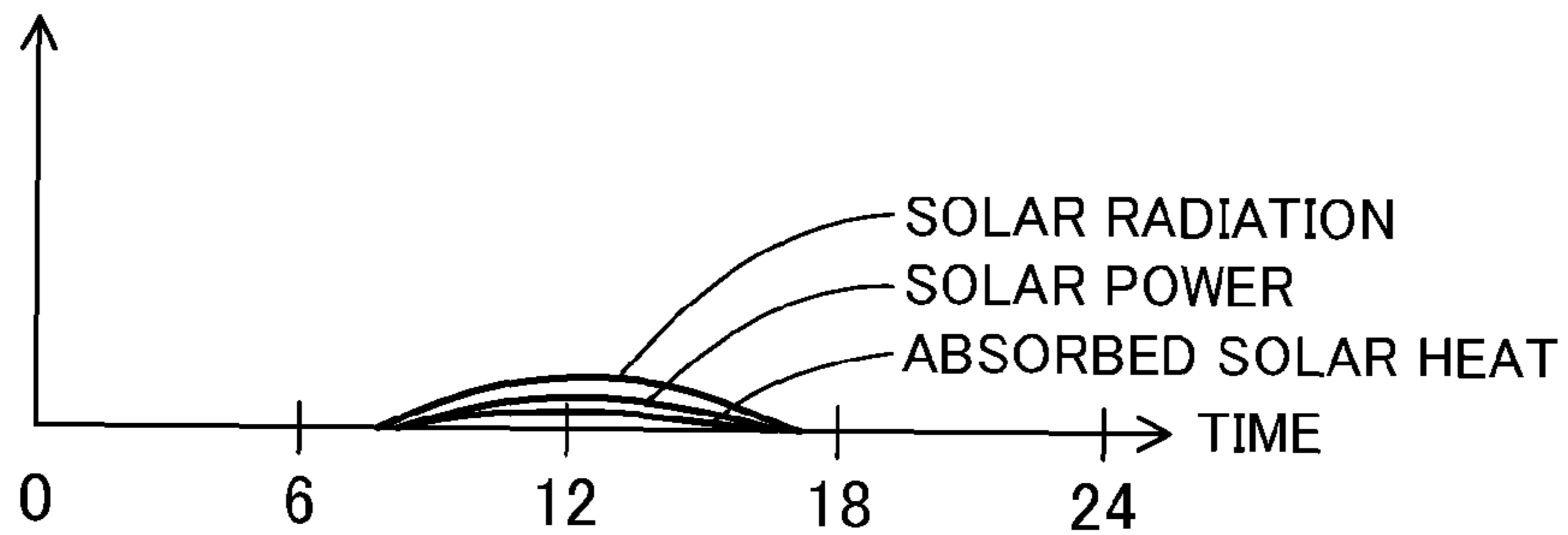
FIG. 1



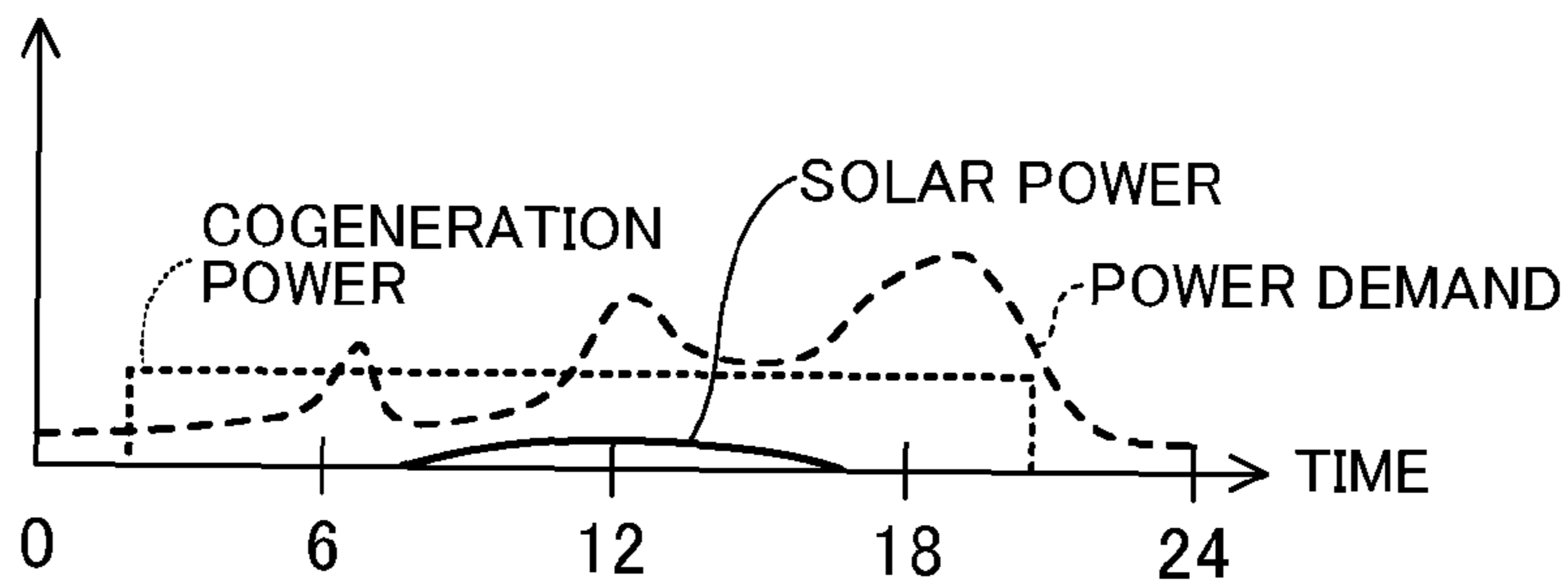
**FIG. 2**



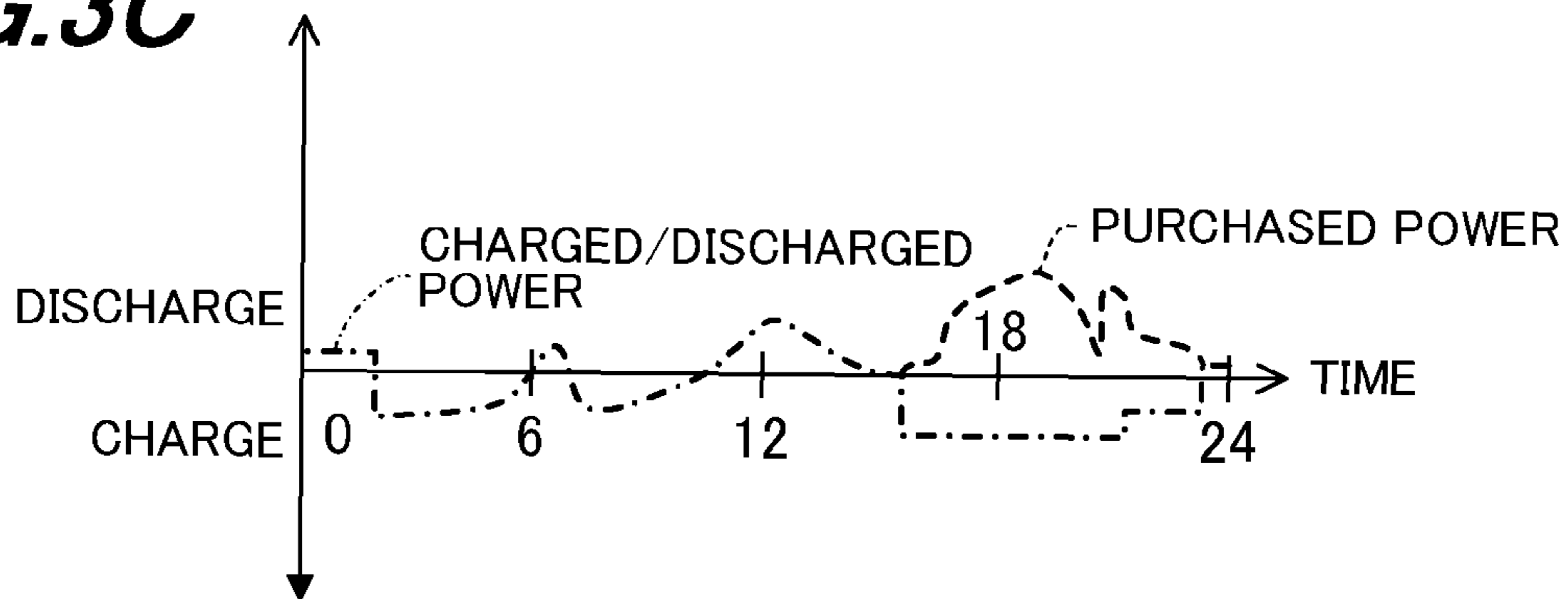
**FIG.3A**



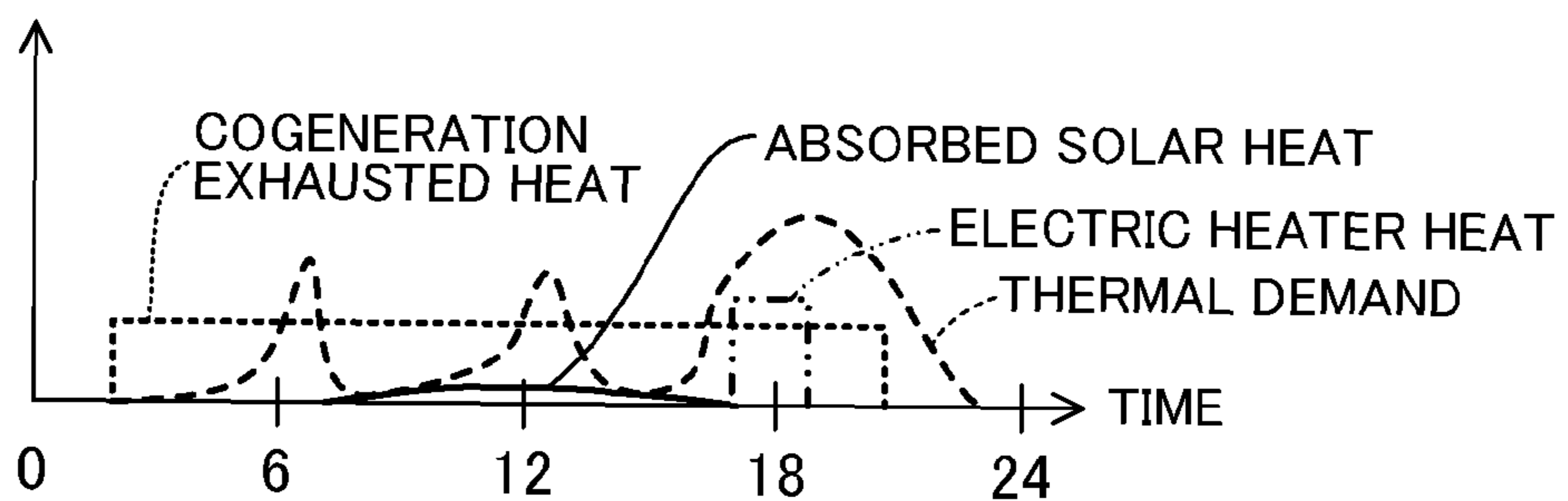
**FIG.3B**



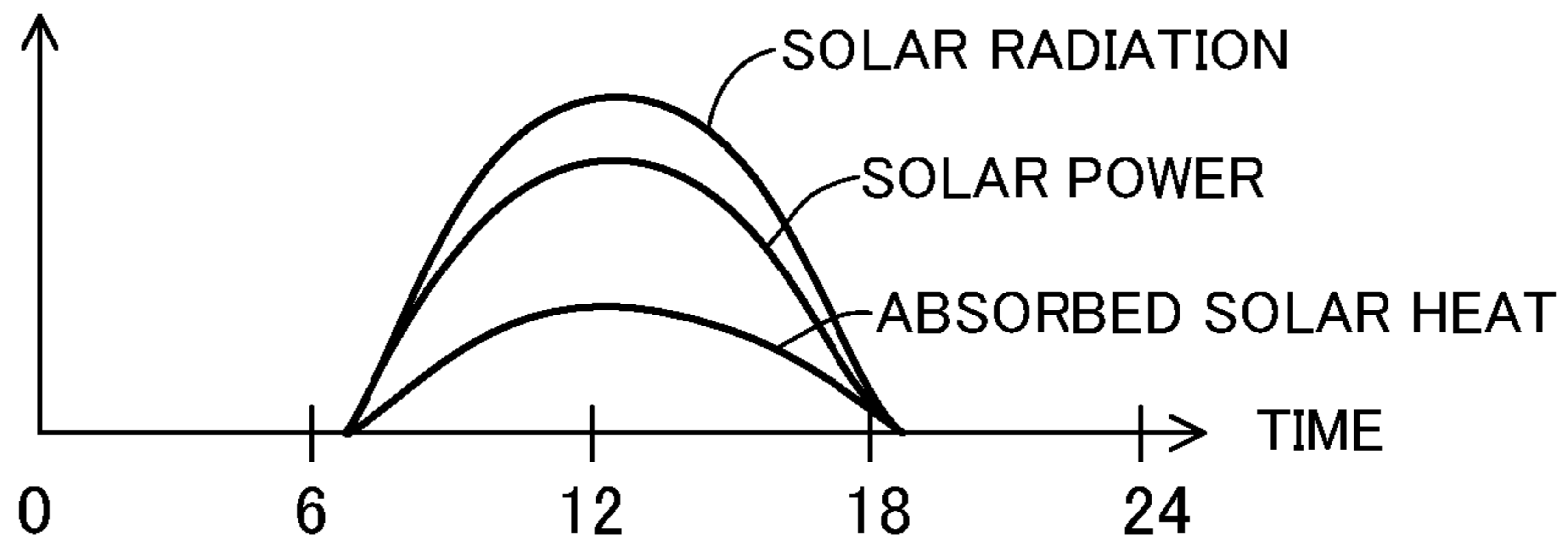
**FIG.3C**



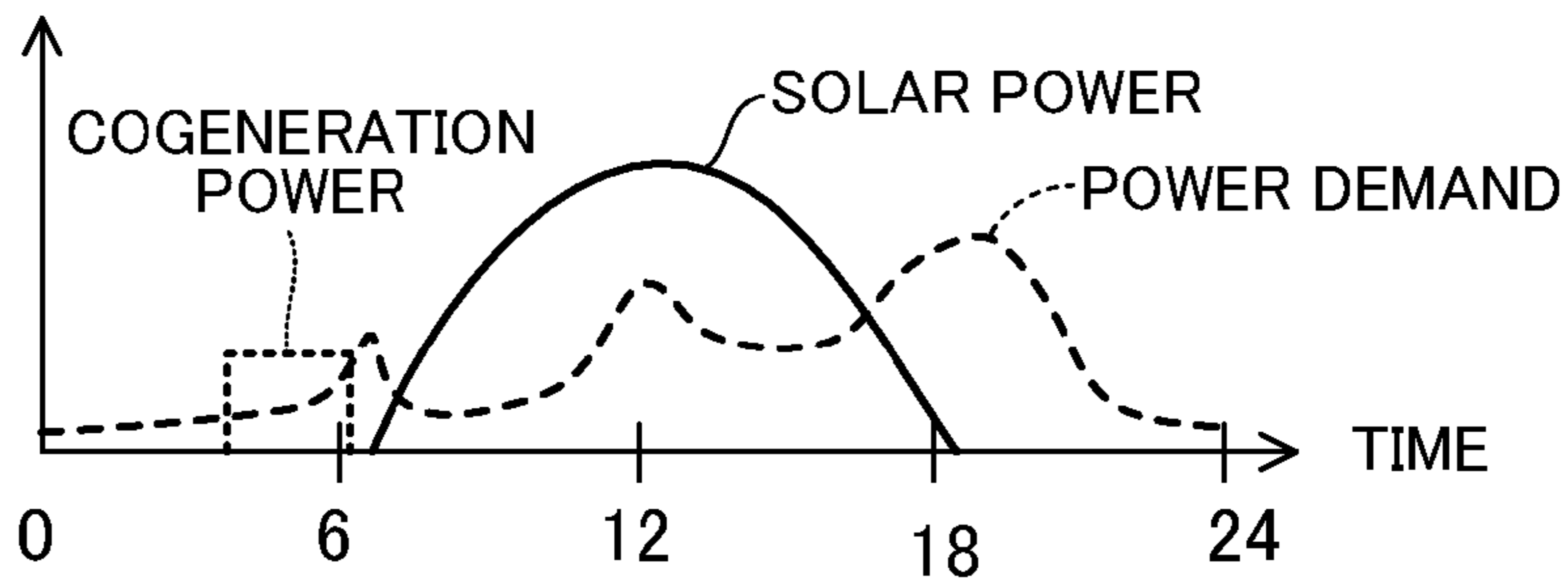
**FIG.3D**



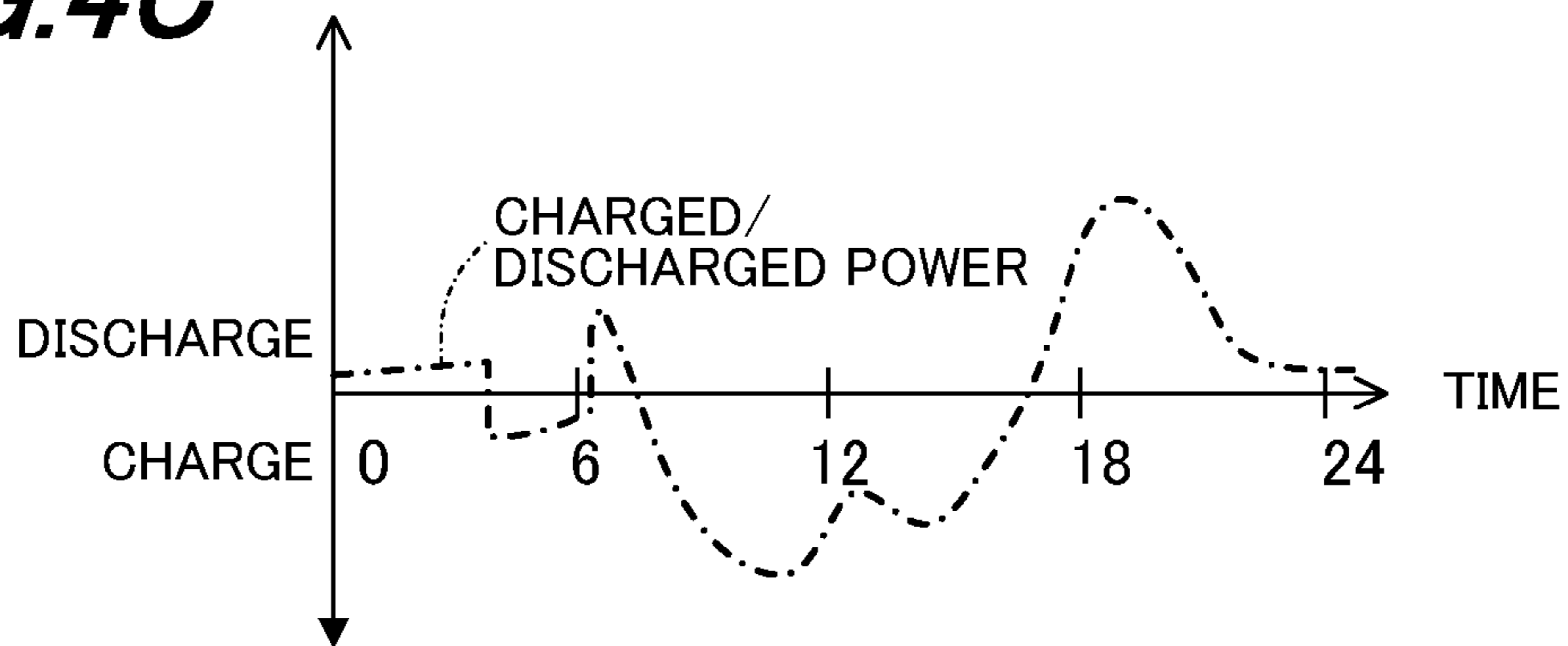
**FIG.4A**



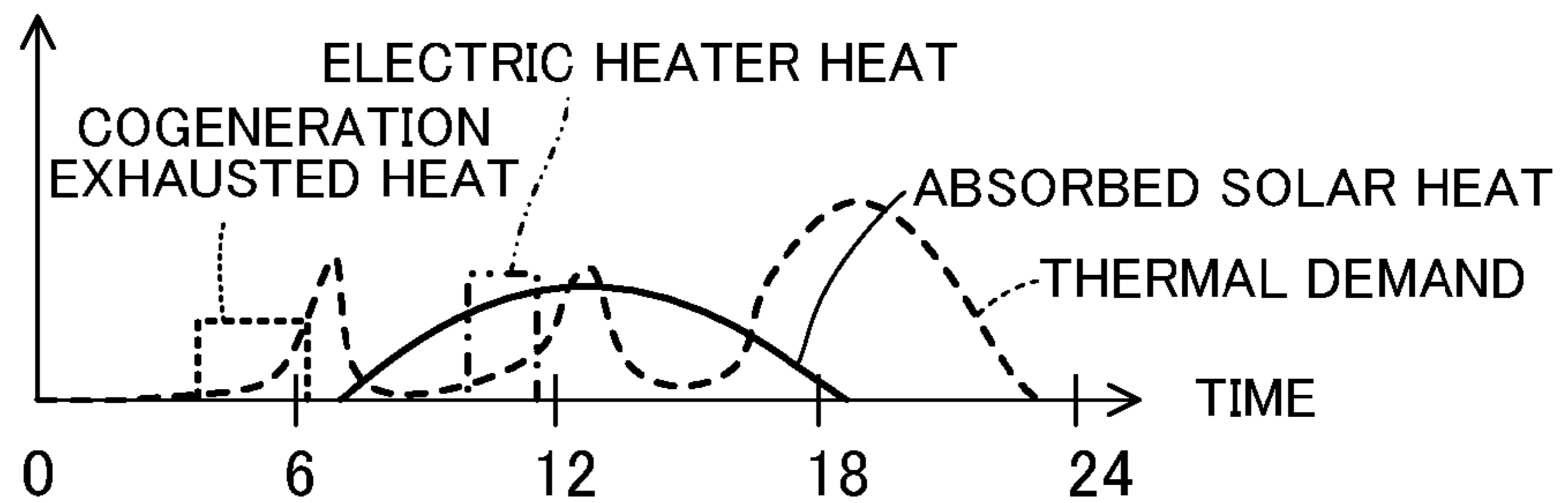
**FIG.4B**



**FIG.4C**



**FIG.4D**



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## POWER SUPPLY SYSTEM

## BACKGROUND OF THE INVENTION

## 1. Field of the Invention

This invention relates to a power supply system, particularly to a distributed power supply system installed at an individual residence to cover power demand of the residence.

## 2. Description of the Related Art

A distributed power supply system, i.e., a power supply system of distributed generation (also called on-site generation) is installed near a place where electric power is needed to generate and supply power thereto. Since the supplied power is consumed at the same location as the place it is generated, the system is superior because the power transmission loss can be suppressed. Such a distributed power supply is taught by, for example, by Japanese Laid-Open Patent Application No. 2003-339118.

In the system disclosed in the reference, a DC bus is connected to a wind-power generation unit and photovoltaic generation unit (power generation unit) and to a load (power destination) to supply power generated by the power generation unit to the load, while connected to a commercial power source via a parallel unit so that, when the voltage of the DC bus is decreased upon increase of power demand, power is supplied from the commercial power source.

The system is also connected to a power storage unit and when the generated power exceeds the power demand and the voltage of the DC bus is increased, stores surplus electricity in the storage unit. When the voltage of the DC bus is further increased, the system transmits the surplus electricity back to the commercial power source to sell. Thus, it is configured to efficiently utilize the surplus electricity.

## SUMMARY OF THE INVENTION

However, since the system in the reference transmits the surplus electricity back to the commercial power source, it causes the power transmission loss and there is still room for improvement.

An object of this invention is therefore to overcome the foregoing problem by providing a power supply system that can effectively utilize surplus electricity without transmitting back the surplus electricity to the commercial power source.

In order to achieve the object, this invention provides a power supply system having a cogeneration unit equipped with an internal combustion engine and a generator driven by the engine to generate power to be supplied to a power destination and hot water to be supplied to a hot water destination by heat exhausted from the engine, comprising: a natural energy generation unit that generates power with natural energy; a power supply unit that receives the power generated by the generator and the natural energy generation unit to supply the received power to the power destination; a connecting bus that electrically connects the cogeneration unit, the natural energy generation unit and the power supply unit; a voltage detector that detects voltage of the power flowing through the connecting bus; and an electric heater that heats the hot water by the power supplied through the connecting bus, wherein the power supply unit controls operation of the electric heater based on the detected connecting bus power voltage.

## BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and advantages of the invention will be more apparent from the following description and drawings in which:

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FIG. 1 is a schematic view giving an overall view of a power supply system according to an embodiment of this invention;

FIG. 2 is a flowchart showing the operation of the system shown in FIG. 1;

FIG. 3 is a set of explanatory views for explaining amounts of power and heat generated by the system shown in FIG. 1 on a bad weather day; and

FIG. 4 is a set of explanatory views for explaining the amounts of power and heat generated by the system shown in FIG. 1 on a good weather day.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A power supply system according to an embodiment of the invention will now be explained with reference to the attached drawings.

FIG. 1 is a schematic view giving an overall view of a power supply system according to an embodiment of this invention. In the drawing, thick solid lines indicate flow of electric power, broken lines signal lines, and thin solid lines flow of liquid such as (hot) water to be supplied and heating medium.

In FIG. 1, reference numeral 10 designates the power supply system. The power supply system 10 comprises a cogeneration unit 12, natural energy generation unit 14, storage unit 16, commercial power unit 18 and power supply unit 20 and also a DC power bus 22 for connecting the foregoing units. The system 10 is a distributed power supply system installed near a place where power is needed, e.g., an individual residence like house.

The cogeneration unit 12 is equipped with a main body 12c having an internal combustion engine (denoted "E" in FIG. 1) 12a and AC generator ("G") 12b driven by the engine 12a, a hot water tank 12d, an exhaust heater (heat exchanger) 12e for heating water in the tank 12d by using exhaust heat exhausted from the engine 12a, an AC/DC converter ("AC/DC") 12f, a DC/DC converter ("DC/DC") 12g, and a controller ("CONT") 12h for controlling the operation of these devices. The engine 12a is a single-cylinder, four-cycle, water-cooled, spark-ignition, OHV engine that runs on city gas or LP (liquefied petroleum) gas and has a displacement of, for example, 163 cc.

The AC power generated by the AC generator 12b is converted to the DC power by the AC/DC converter 12f and boosted or stepped up to a predetermined voltage (e.g., 750V) by the DC/DC converter 12g. The boosted DC power is sent to the DC power bus 22.

The exhaust heat of the engine 12a is forwarded through a coolant passage 12a1 of the engine 12a to the exhaust heater 12e, where it is heat-exchanged with heating medium flowed therein. The heating medium heated through the heat exchange is sent to the tank 12d to heat water therein (to generate hot water).

The cogeneration unit 12 is further equipped with a solar heater 12i that heats the heating medium. The solar heater 12i has a case of flat box shape which is, for instance, 2 meters wide, 1 meter long and 0.1 meter high and is attached on its top surface with a glass plate. The solar heater 12i is installed outside at a sunny location such as rooftop of the residence and heats the heating medium filled in the case by solar heat. Ethylene glycol solution is used as the heating medium.

The tank 12d is connected to a water supply pipe 12j for leading water from a water supply source and a hot water supply pipe 12k for supplying heated hot water to a hot water destination (load). The water supply pipe 12j is provided with

a feed-water valve (open/close valve) **12j1** and when it is opened, water is supplied from the water supply source to the tank **12d**. The hot water supply pipe **12k** is similarly provided with a feed-hot-water valve (open/close valve) **12k1** and when it is opened, hot water is supplied to the hot water destination.

The tank **12d** is further installed with an electric heater **12l** having an electric heating wire. The electric heater **12l** is connected to the DC power bus **22** to be operated with power supplied therethrough to further heat the water which has been heated through heat exchange.

A thermometer **12m** and water gauge **12n** are installed at the tank **12d** and produce outputs indicative of the temperature and quantity of water stored in the tank **12d**, respectively. The outputs of the thermometer **12m** and water gauge **12n** are sent to the controller **12h**.

The controller **12h** which has a microcomputer including a CPU, ROM, memory, input/output circuits and other devices monitors the operation of the AC/DC converter **12f** and DC/DC converter **12g** and when overvoltage or overcurrent is detected, disconnects the power transmission to the DC power bus **22**. The controller **12h** controls the operation of the engine **12a** and valves **12j1**, **12k1** based on operation setting data (explained later) and inputted outputs, and controls the operation of the electric heater **12l** in association with a controller (explained later) of the power supply unit **20**.

The natural energy generation unit **14** is equipped with a photovoltaic generator **14a** installed outside at a sunny location such as rooftop of the residence for generating power through sunlight, a DC/DC converter **14b** and a controller **14c** for controlling the operation of these devices. The generator **14a** is also installed outside at a sunny location such as rooftop of the residence.

The DC power generated by the photovoltaic generator **14a** is boosted or stepped up to a predetermined voltage (e.g., 750V) by the DC/DC converter **14b** and the boosted DC power is sent to the DC power bus **22**. The controller **14c** monitors the operation of the photovoltaic generator **14a** and DC/DC converter **14b** and when overvoltage or overcurrent is detected, disconnects the power transmission to the DC power bus **22**.

The storage unit **16** is equipped with a chargeable/dischargeable battery (e.g., a lead-acid battery) **16a**, a DC/DC converter **16b** and a controller **16c** for controlling the operation of these devices. The battery **16a** is connected to the DC power bus **22** through the DC/DC converter **16b**. When the battery **16a** is discharged, the discharged power is boosted or stepped up to a predetermined voltage (e.g., 750V) by the DC/DC converter **16b** and sent to the DC power bus **22**. When the battery **16a** is charged, the power from the DC power bus **22** is stepped down by the DC/DC converter **16b** and transmitted to the battery **16a**.

The controller **16c** is connected to a voltage sensor (denoted "V1" in FIG. 1) **22a** installed at the DC power bus **22** and produces an output indicative of voltage V1 of power flowing through the bus **22**. The output is sent to the controller **16c** and based on the output, the controller **16c** determines whether the battery **16a** is charged or discharged and sends a charge/discharge switch command (or a no charge/discharge command) to the DC/DC converter **16b**. Specifically, the controller **16c** sends the charge/discharge switch command to the DC/DC converter **16b** in association with the controller (explained later) of the power supply unit **20**. A voltage sensor (denoted "V2") **16d** is installed at the battery **16a** and produces an output indicative of voltage V2 of power stored therein. The output is also sent to the controller **16c**.

The commercial power unit **18** is equipped with an AC/DC converter **18a**, a DC/DC converter **18b** and a controller **18c** for controlling the operation of these devices. The AC/DC converter **18a** is connected to a commercial power source **24** to convert the AC power supplied therefrom to the DC power. The converted DC power is boosted or stepped up to a predetermined voltage (e.g., 750V) by the DC/DC converter **18b** and the boosted DC power is sent to the DC power bus **22**. The controller **18c** monitors the operation of the AC/DC converter **18a** and DC/DC converter **18b** and when overvoltage or overcurrent is detected, disconnects the power transmission to the DC power bus **22**. Further, the controller **18c** sends a command for transmitting power to the DC power bus **22** (power transmission command) to the DC/DC converter **18b** in association with the controller (explained later) of the power supply unit **20**. Unless the power transmission command is issued, the commercial power is not transmitted to the DC power bus **22**.

The power supply unit **20** is equipped with a DC/AC converter (denoted "DC/AC" in FIG. 1) **20a** and a controller **20b** for controlling the operation thereof. The DC/AC converter **20a** is connected to the DC power bus **22** to be supplied with the DC power from the foregoing units. The supplied DC power is converted to the AC power by the DC/AC converter **20a** to be supplied to a power destination (load where power is needed) in the individual residence. The controller **20b** monitors the operation of the DC/AC converter **20a** and when overvoltage or overcurrent is detected, disconnects the power transmission to the power destination.

The controller **20b** is connected to a data input device **20c** that inputs the operation setting data of the power supply system **10** and a display **20d** that displays the data and operating condition of the system **10**. The operation setting data includes various predetermined voltages (explained later), hot water supply start time of the cogeneration unit **12** and thermal demand (amount and temperature of hot water). The controller **20b** is also provided with a communication device **20e** capable of transmitting/receiving data to/from an external computer.

The controller **20b** is connected to the controllers **12h**, **14c**, **16c**, **18c** of the foregoing units to be able to communicate and based on the operation setting data and the outputs sent from the units, sends commands to the units to control the units collectively. In particular, based on the outputs indicative of voltages V1, V2 sent from the storage unit **16**, the controller **20b** controls the operation of the electric heater **12l**, charge/discharge of the storage unit **16**, and power transmission of the commercial power unit **18**.

Like the controller **12h**, other controllers **14c**, **16c**, **18c** and **20b** are each provided with a CPU, ROM, memory, input/output circuits and other devices.

FIG. 2 is a flowchart showing the operation of the system **10**. The illustrated program is executed by the controller **20b** when the system **10** is powered ON (activated).

The program begins at S10, in which it is determined whether the voltage V1 of the DC power bus **22** is equal to or less than a predetermined voltage a (e.g., 700 V). The voltage V1 is decreased when an amount of power consumed at the power destination exceeds that generated by the AC generator **12b** and photovoltaic generator **14a**. Therefore, when the result in S10 is affirmative, the program proceeds to S12, in which the storage unit **16** is controlled to discharge. Specifically, since the generated power is insufficient for the power demand, the voltage V1 is increased.

The program then proceeds to S14, in which it is determined whether the voltage V2 of the battery **16a** is equal to or less than a predetermined voltage **13** (e.g., 10 V). Since the

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voltage V2 is decreased with decreasing amount of stored power, when the result in S14 is affirmative, the program proceeds to S16, in which the commercial power unit 18 is controlled to transmit power, i.e., a command is issued so that power from the commercial power source 24 is purchased and transmitted to the DC power bus 22. When the result in S14 is negative, since the stored power amount in the battery 16a is sufficient, the step of S16 is skipped and the program is terminated.

When the result in S10 is negative, the program then proceeds to S18, in which it is determined whether the voltage V1 of the DC power bus 22 is equal to or greater than a predetermined voltage  $\gamma$  (e.g., 750 V). The voltage V1 is increased when the amount of power generated by the AC generator 12b and photovoltaic generator 14a exceeds that consumed at the power destination. Therefore, when the result in S18 is affirmative, the program proceeds to S20, in which the storage unit 16 is controlled to charge. Specifically, the surplus electricity is stored to decrease the voltage V1.

The program then proceeds to S22, in which it is determined whether the voltage V2 of the battery 16a is equal to or greater than a predetermined voltage  $\delta$  (e.g., 15 V). Since the voltage V2 is increased with increasing amount of stored power, when the result in S22 is affirmative, it is determined that the battery 16a is fully charged and the program proceeds to S24, in which a command is sent to the cogeneration unit 12 to operate the electric heater 12l to on.

Specifically, when the both voltages V1, V2 are equal to or greater than the predetermined voltages  $\gamma$ ,  $\delta$ , the surplus electricity resulted from power generation of the AC generator 12b and photovoltaic generator 14a is converted to heat through the electric heater 12l to heat water in the tank 12d.

When the result in S22 is negative, since it means that the battery 16a is not fully charged and still able to store the surplus electricity, the step of S24 is skipped and the program is terminated.

When the result in S18 is negative, since the power consumed at the power destination and the power generated by the AC generator 12b and photovoltaic generator 14a are balanced, it is determined that charge/discharge of the battery 16a is not necessary and the program is terminated.

The explanation on the amounts of power and heat generated by the power supply system 10 will be made separately for the cases of a bad weather day and good weather day.

FIG. 3 is a set of explanatory views for explaining the amounts of power and heat generated by the system 10 on a bad weather day.

FIG. 3A is a graph showing amounts of solar radiation, solar power generated by the photovoltaic generator 14a and heat (absorbed solar heat) absorbed by the solar heater 12i. FIG. 3B is a graph showing amounts of power (cogeneration power) generated by the AC generator 12b of the cogeneration unit 12, solar power and power consumed at the power destination (power demand).

FIG. 3C is a graph showing amounts of charged/discharged power of the battery 16a and transmitted power (purchased power) from the commercial power unit 18. FIG. 3D is a graph showing amounts of exhausted heat (cogeneration exhausted heat) from the engine 12a of the cogeneration unit 12, absorbed solar heat, heat (electric heater heat) generated by the electric heater 12l and heat corresponding to hot water demand (thermal demand).

As illustrated, on a bad weather day, since the power generation by the photovoltaic generator 14a and the heat absorption by the solar heater 12i can not be expected, the cogeneration unit 12 is to be operated for a long period of time. The operating time of the cogeneration unit 12 is calculated from

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a heat amount stored in the tank 12d (which is estimated based on the outputs of the thermometer 12m and water gauge 12n), a heat amount required on that day (which is estimated based on the operation setting data) and an absorbed heat amount expected for the solar heater 12i (which is estimated based on solar radiation data with respect to different weathers prepared beforehand).

Upon start of the operation of the cogeneration unit 12, the voltage V1 of the DC power bus 22 is increased to exceed the predetermined voltage  $\gamma$  and it makes the battery 16a in discharged condition to be in charged condition temporarily. Then, when the power demand is increased so that the voltage V1 is decreased to or below the predetermined voltage  $\alpha$ , it makes the battery 16a discharged.

After that, when the power demand is further increased, the voltage V2 of the battery 16a is decreased to or below the predetermined voltage  $\beta$  and power is purchased from the commercial power source 24. The battery 16a is in the charged condition during power purchase.

When the cogeneration exhausted heat and absorbed solar heat can not meet the thermal demand, power is supplied from the DC power bus 22 to operate the electric heater 12l.

FIG. 4 is a set of explanatory views similar to FIG. 3 for explaining the amounts of power and heat generated by the system 10 on a good weather day.

On a good weather day, since the power generation by the photovoltaic generator 14a and the heat absorption by the solar heater 12i can be expected, the cogeneration unit 12 is operated only for a short period of time.

Specifically, although the cogeneration unit 12 is started in the morning for supplying hot water, it is stopped after a short while. Even though the cogeneration unit 12 is stopped, since the amount of solar power is greater than the power demand, the voltage V1 becomes the predetermined voltage  $\gamma$  or more and it makes the battery 16a to be in the charged condition.

When, subsequently, the voltage V2 of the battery 16a becomes the predetermined voltage  $\delta$  or more and the battery 16a is fully charged, the electric heater 12l is operated so that the surplus electricity is converted to heat and stored in the tank 12d. As a result, even when the thermal demand is increased later, it is not necessary to operate the cogeneration unit 12. Specifically, power generated by the photovoltaic generator 14a can be efficiently used to the utmost extent, without loss.

As stated above, the embodiment is configured to have a power supply system (10) having a cogeneration unit (12) equipped with an internal combustion engine (12a) and a generator (AC generator 12b) driven by the engine to generate power to be supplied to a power destination (load) and hot water to be supplied to a hot water destination (load) by heat exhausted from the engine, characterized by: a natural energy generation unit (14) that generates power with natural energy; a power supply unit (20) that receives the power generated by the generator (12b) and the natural energy generation unit (14) to supply the received power to the power destination; a connecting bus (DC power bus 22) that electrically connects the cogeneration unit, the natural energy generation unit and the power supply unit; a voltage detector (voltage sensor 22a) that detects voltage (V1) of the power flowing through the connecting bus; and an electric heater (12l) that heats the hot water by the power supplied through the connecting bus, wherein the power supply unit (20) controls operation of the electric heater based on the detected connecting bus power voltage (S10-S24).

In other words, it is configured so that, based on the detected voltage (V1) of the connecting bus (DC power bus 22), it is determined whether or not the surplus electricity is



generated and when the surplus electricity is generated, the electric heater (12*l*) is operated to on to convert the surplus electricity to heat for increasing the temperature of water to be supplied. With this, it becomes possible to suppress the power transmission loss of the surplus electricity and utilize the surplus electricity more effectively than transmitting it back to the commercial power source 24.

Further, since the surplus electricity is used to heat water to be supplied, it becomes possible to shorten the operating time of the cogeneration unit (12), thereby enabling to utilize the natural energy to the utmost extent, without loss.

The system further includes: a storage unit (16) that is connected to the connecting bus and stores the power not supplied to the power destination; and the power supply unit (20) controls operation of the storage unit based on the detected connecting bus power voltage (S10-S20).

Specifically, in the system, the power supply unit (20) controls the operation of the storage unit to discharge the stored power when the detected connecting bus power voltage (V1) is equal to or less than a predetermined voltage (a). More specifically, the system further includes: a storage unit (16) that is connected to the connecting bus and stores the power not supplied to the power destination; and a detector (16*d*) that detects voltage (V2) of the power stored in the storage unit, and the power supply unit (20) controls the operation of the electric heater (12*l*) based on the detected stored power voltage (S10-S24).

Still more specifically, in the system, the power supply unit (20) controls the operation of the electric heater (12*l*) to on when the detected connecting bus power voltage (V1) exceeds a predetermined first voltage ( $\alpha$ ) and the detected stored power voltage (V2) exceeds a predetermined second voltage ( $\beta$ ) (S10-S24).

Yet still more specifically, in the system, the power supply unit (20) controls the operation of the electric heater (121) to on when the detected connecting bus power voltage (V1) exceeds a predetermined first voltage ( $\alpha$ ), but is equal to or greater than a predetermined third voltage ( $\gamma$ ), and the detected stored power voltage (V2) exceeds a predetermined fourth voltage ( $\delta$ ) (S10-S24).

Thus, since it is configured so that, based on the stored power voltage (V2) of the storage unit (16), it is determined whether the surplus electricity is generated, the surplus electricity generation can be appropriately determined and hence, it becomes possible to effectively utilize the surplus electricity through the electric heater (12*l*).

In the system, the connecting bus (22) is connected to a commercial power source (24) and the power supply unit (20) determines whether or not to receive power from the commercial power source based on the detected connecting bus voltage (V1) and the detected stored power voltage (V2) (S10-S16). More specifically, the power supply unit (20) determines to receive the power from the commercial power source when the detected connecting bus power voltage (V1) is equal to or less than a predetermined first voltage ( $\alpha$ ) and the detected stored power voltage (V2) is equal to or less than a predetermined second voltage ( $\beta$ ).

Since it is configured to use power from the commercial power source (24) when the increase of power demand is determined based on the detected voltages (V1, V2) of the connecting bus (22) and storage unit (16), it becomes possible to surely supply power to the power destination even in the case that the power demand is increased.

In the system, the natural energy generation unit (14) comprises a photovoltaic generator (14*a*). With this, since it is configured to generate power through sunlight, it becomes

possible to achieve high energy efficiency compared to power generation using other kinds of natural energy.

In the system, the cogeneration unit (12) has a solar heater (12*i*) that heats the water with solar heat. With this, it becomes possible to heat water to be supplied further using natural energy.

It should be noted that, in the foregoing embodiment, although the natural energy generation unit 14 is configured to be constituted as the photovoltaic generator 14*a*, it may instead be an aerogenerator or a geothermal generator. Alternatively, a plurality of number of the natural energy generation units may be connected to the DC power bus 22.

It should also be noted that, although the battery 16*a* is to be in the charged condition during power purchase, in order to keep cost low on power purchase, it is not necessarily to be in the charged condition.

It should further be noted that, instead of the Ethylene glycol solution, other liquid or gas may be applied as the heating medium.

Japanese Patent Application No. 2009-185137 filed on Aug. 7, 2009, is incorporated by reference herein in its entirety.

While the invention has thus been shown and described with reference to specific embodiments, it should be noted that the invention is in no way limited to the details of the described arrangements; changes and modifications may be made without departing from the scope of the appended claims.

What is claimed is:

1. A power supply system, comprising:

- a cogeneration unit equipped with;
    - an internal combustion engine,
    - a generator driven by the engine to generate power to be supplied to a power destination,
    - a hot water tank for supplying hot water to a hot water destination by selectively using heat exhausted from the engine and an electric heater to heat the hot water, and
  - a cogeneration unit (CU) controller for controlling the operation of the cogeneration unit;
  - a natural energy generation unit that generates power with natural energy;
  - a power supply unit, including a power supply unit (PSU) controller, that receives the power generated by the generator and the natural energy generation unit to supply the received power to the power destination;
  - a connecting bus that electrically connects the cogeneration unit, the natural energy generation unit and the power supply unit;
  - a voltage detector that detects voltage of the power flowing through the connecting bus;
- wherein the power supply unit controller controls operation of the electric heater based on the detected connecting bus power voltage.

2. The system according to claim 1, further including:

- a storage unit that is connected to the connecting bus and stores the power not supplied to the power destination;
- and the power supply unit controller controls operation of the storage unit based on the detected connecting bus power voltage.

3. The system according to claim 2, wherein the power supply unit controller controls the operation of the storage unit to discharge the stored power when the detected connecting bus power voltage is equal to or less than a predetermined voltage.

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4. The system according to claim 1, further including:  
 a storage unit that is connected to the connecting bus and  
 stores the power not supplied to the power destination;  
 and  
 a detector that detects voltage of the power stored in the  
 storage unit,  
 and the power supply unit controller controls the operation  
 of the electric heater based on the detected stored power  
 voltage.

5. The system according to claim 4, wherein the power  
 supply unit controller controls the operation of the electric  
 heater to on when the detected connecting bus power voltage  
 exceeds a predetermined first voltage and the detected stored  
 power voltage exceeds a predetermined second voltage.

6. The system according to claim 5, wherein the power  
 supply unit controller controls the operation of the electric  
 heater to on when the detected connecting bus power voltage  
 exceeds the predetermined first voltage, but is equal to or  
 greater than a predetermined third voltage, and the detected  
 stored power voltage exceeds the predetermined second volt-  
 age.

7. The system according to claim 4, wherein the connecting  
 bus is connected to a commercial power source and the power

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supply unit controller determines whether or not to receive  
 power from the commercial power source based on the  
 detected connecting bus voltage and the detected stored  
 power voltage.

8. The system according to claim 7, wherein the power  
 supply unit controller determines to receive the power from  
 the commercial power source when the detected connecting  
 bus power voltage is equal to or less than a predetermined first  
 voltage and the detected stored power voltage is equal to or  
 less than a predetermined second voltage.

9. The system according to claim 1, wherein the natural  
 energy generation unit comprises a photovoltaic generator.

10. The system according to claim 1, wherein the cogen-  
 eration unit has a solar heater that heats the water with solar  
 heat.

11. The system according to claim 1, wherein the PSU  
 controller is communicatively coupled with the CU controller  
 and interfaces with the CU controller to control the operation  
 of the electric heater.

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